Flowers and insects. V.

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Astragalus Mexicanus A. DC.—The flowers are cream-color, often with a bluish tinge at the tip of the keel. The wings and keel are closely fastened together, so that they must be depressed simultaneously. The rigid banner is folded over the wings and keel, and projects straight forward in front of the calyx tube. This tube measures about 8 mm., and the parts of the flower are so contracted beyond it that after a bee has forced its head in so as to touch the anthers, it still needs a proboscis 10 to 13 mm. long to obtain the sweets. The petals are thus disposed so as to limit the accessibility of the nectar and to restrict the place of pollen-contact to the underside of the bee's head. The stigma only slightly surpasses the anthers and may touch the bee a little in advance of them, but self-pollination may occur in absence of insects.

The flower is adapted to the longest-tongued bees. From its early blooming it is especially exposed to Bombus females and to species of Synhalonia. On three days, April 27, 30, and May 2, I observed the following visitors:

Hymenoptera—*Apidæ:* (1) Bombus separatus Cr. ♀, s., once; (2) B. americanorum F. ♀, s. ab.; (3) B. pennsylvanicus DeG. ♀, s.; (4) Synhalonia speciosa Cr. ♂ ♀, s., ab.; (5) S. atriventris Sm. ♀, s. and c. p., very ab.

Four butterflies were seen sucking, viz.: Papilio asterias, Colias philodice, Nisoniades icelus and N. juvenalis, but they are mere intruders, since they steal the honey without forcing down the keel.

Strophostyles angulosa Ell.[1]—The keel is bent strongly to the right and curves around so that its tip stands over its base. The base is large and sack-like and is produced above into a ridge which opposes the passage to the nectary. The left wing is turned to the right, so that the bee is required to alight upon the right side, and she enters the flower between the tip and the basal process of the keel. Seizing this process with her front feet, the bee pulls the keel downward and backward, whereupon the stigma and the pollen-laden brush of the style sweep out over her thorax. In this way the stigma receives pollen already deposited by an-

[1] This flower is described by Foerste in Am. Nat. XIX, 887, 888, figs. 1-5. I did not see a bee depress the keel in the way described by him.

other flower, and the style-brush leaves a new load. As soon as the bee lets go her hold upon the basal process, the keel returns to its place against the banner, and the style draws back into it.

Visitors: Hymenoptera—*Apidæ:* (1) Megachile brevis Say ♀, s. and c. p.; (2) M. exilis Cr. ♂, s.

Extranuptial nectaries.[2]—The following insects were taken while obtaining nectar from these structures:

Hymenoptera—*Andrenidæ:* (1) Augochlora pura Say; (2) Halictus flavipes F.; (3) H. confusus Sm. *Vespidæ:* (4) Vespa germanica F.; (5) Polistes pallipes St. Farg. *Eumenidæ:* (6) Odynerus pedestris Sauss. *Crabronidæ:* (7) Oxybelus 4-notatus Say. *Philanthidæ:* (8) Philanthus punctatus Say; (9) Cerceris clypeata Dahlb.; (10) C. kennicottii Cr.: (11) C. finitima Cr. *Larridæ:* (12) Larra acuta Patton. *Sphecidæ:* (13) Pelopocus cementarius Dru.; (14) Chalybion cæruleum L. *Pompilidæ:* (15) Agenia longula Cr. *Mutillidæ:* (16) Sphærophthalma macra Cr. *Formicidæ:* (17) A black species not abundant enough to interfere with other insects or to suggest a thought of myrmecophilism. *Chrysididæ:* (18) Hedychridium dimidiatum Say. *Braconidæ:* (19) Apanteles sp.; (20) Microdus sp.

Diptera—*Syrphidæ:* (21) Mesograpta marginata Say. *Empidæ:* (22) Empis sp. *Tachinidæ:* (23) Eggeria? sp. *Sarcophagidæ:* (24–25) Sarcophaga spp. *Muscidæ:* (26) Lucilia cornicina F. *Anthomyidæ:* (27) Anthomyia sp. *Ortalidæ:* (28) Camptoneura picta F.; (29) Rivellia quadrifasciata Macq. *Geomyzidæ:* (30) sp. *Drosophilidæ:* (31–32) spp.

Hemiptera—*Capsidæ:* (33) Lygus pratensis L.

Amphicarpæa Pitcheri[3] Torr. & Gray.—The pale blue flowers are approximated in a rather close raceme, so that the attractive function is performed by the inflorescence and does not depend especially upon the banner, as in solitary flowers. For the same reason the wings and keel are relieved of their special office of affording a landing-place for the bees to settle upon. Accordingly, these insects alight upon the flower-cluster and crawl from one flower to another. The calyx-tube is very long (6 mm.), which makes the nectar inaccessible to short-tongued visitors. The petals, also, being freed from their original functions by the flower-cluster, are disposed so as to make the nectar still more

[2] For a resume of the subject of extranuptial nectaries and for reference to the literature see Trelease: Myrmecophilism, Psyche Feb.-March, 1889, 171-180.

[3] On the fertilization of A. monoica, see Meehan: Proc. Acad. Nat. Sci. Phila., 1887, 323-325.

inconvenient for short tongues and to limit the place of pollen-contact to the underside of the visitor's head. The broad banner is folded over the other parts and is held tightly by the calyx-tube, so that with the closely approximated wings and keel it makes it difficult for a visitor with a proboscis shorter than 11 mm. to reach the nectar.

The flower is visited for nectar by *Bombus americanorum* F. ♂ ♀, and by the ruby-throated humming bird, *Trochilus colubris* L.

Cercis Canadensis L.—The red-purple flowers cover the trees before their own leaves and those of other trees appear. The trees can then be seen for miles and must attract bees from afar. The stamens are distinct and not firmly enclosed by the petals, and the calyx is broad and shallow. Accordingly, both honey and pollen are accessible to small and little specialized bees, like Halictus.

Although one of the least specialized of Leguminosæ, Cercis shows one of the most peculiar sets of visitors—the effect of early blooming. Of the bees with abdominal pollen-brushes, which are very fond of flowers of Papilionaceæ, Osmia, which flies in early spring, is abundant, while Megachile, which flies in summer, is absent. Later blooming species are visited by Megachile, while Osmia is absent. Cercis also resembles early flowers by being visited only by females of Bombus, while many flowers blooming in summer are visited by the males and workers. Synhalonia, and Anthophora also as far as I have observed, is only found on early flowers. If Cercis bloomed in summer, I should expect also to find Sphecidæ among its guests, as in the cases of Amorpha and Petalostemon. The flower is further remarkable for being abundantly visited by Colletes, C. inæqualis being more common on it than on any other flower known to me.

On six days, between April 21 and May 5, I captured the following visitors:

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s. and c. p., ab.; (2) Bombus virginicus Oliv. ♀, s.; (3) B. separatus Cr. ♀, s. and c. p.; (4) B. vagans Sm. ♀, s.; (5) B. americanorum F. ♀, s., ab.; (6) B. pennsylvanicus DeG. ♀, s., ab.; (7) Anthophora ursina Cr. ♂ ♀, s., freq.; (8) Synhalonia speciosa Cr. ♂ ♀, s. and c. p., ab.; (9) S. honesta Cr. ♂, s.; (10) Ceratina dupla Say ♂, s.; (11) Osmia lignaria Say ♂ ♀, s. and c. p.; (12) O. atriventris Cr. ♀, s. and c. p.; (13) O. albi-

ventris Cr. ♀, s. and c. p.; (14) O. latitarsis Cr. ♂, s.; (15) Nomada luteola St. Farg. ♂ ♀, s.; (16) N. bisignata Say ♂ ♀, s. *Andrenidæ:* (17–18) Andrena spp. ♀, s. and c. p.; (19) A. hirticeps Sm. ♀, s.; (20) A. valida Say ♀, s. and c. p.; (21) Augochlora labrosa Say ♀, s.; (22) Halictus coriaceus Sm. ♀, s.; (23) H. lerouxii St. Farg. ♀, s. and c. p.; (24) H. flavipes F. ♀, s. and c. p., ab.; (25) H. zephyrus Sm. ♀, s.; (26) H. pilosus Sm. ♀, s. and c. p.; (27) H. confusus Sm. ♀, s. and c. p.; (28) H. stultus Cr. ♀, s. and c. p., ab.; (29) Colletes inæqualis Say ♂ ♀, s. and c. p., ab.; (30) C. canadensis Cr. ? ♀, s. and c. p. *Vespidæ:* (31) Polistes pallipes St. Farg. s.

Diptera—*Bombylidæ:* (32) Bombylius fratellus Wied., s. *Empidæ:* (33) Empis sp., s.

Lepidoptera—*Rhopalocera:* (34) Lycæna comyntas Godt.; (35) Nisoniades icelus Lintn., both s.

Coleoptera—*Cerambycidæ:* (36) Molorchus bimaculatus Say.

Cassia Chamaecrista L.[4]—The sickle-shaped pistil is turned either to the right or to the left, holding the stigma in such a position that it touches the bee upon the side: the flower is therefore an example of what Delpino calls a *pleurotribe* flower. Ten long black anthers with terminal pores turn in an opposite direction from the pistil. The petals are bright yellow, the upper ones are provided with a little red at base which serves as a path-finder, but not as a nectar-guide, since nectar is wanting. All are widely expanded and flexible except the lateral one toward which the anthers turn, which is erect and strongly incurved and so stiff that it commonly breaks on being bent back.

The flowers are visited exclusively by bumble-bee females and workers in search of pollen. Landing upon the anthers they seize them between their mandibles and stroke them downwards with a sort of milking motion. The pollen being thus forced out of the terminal anther-pores falls either directly upon the bee or upon the lateral petal which is pressed close against the bee's side. In this way the side of the bee which is next to the incurved petal receives the most pollen. Both right and left-hand flowers are found upon the same plant. A bee visiting a left-hand flower receives pollen upon the right side and then flying to a right-hand flower, strikes the same side against the stigma.

[4] See J. E. Todd. On the flowers of Solanum rostratum and Cassia Chamæcrista, Am. Nat. XVI, 281-287. fig. 2.

Visitors: *Apidae*: (1) Bombus virginicus Oliv. ☿; (2) B. separatus Cr. ☿; (3) B. americanorum F. ♀☿; (4) B. scutellaris Cr. ☿—all c. p. Megachile brevis Say ♀ mutilates the petals by cutting out large circular pieces to use in her nest

Extranuptial nectaries.—The extrafloral nectaries of this plant and of C. Marilandica are situated on the upper side and near the base of the petioles, being cupuliform in Chamæcrista and club-shaped in Marilandica.

Visitors: (Aug. 2, 7, 8) Hymenoptera—*Andrenidæ*: (1) Halictus confusus Sm. *Eumenidæ*: (2) Odynerus foraminatus Sauss. *Larridæ*; (3) Larra argentata Beauv. *Sphecidæ*: (4) Pelopocus cementarius Dru.; (5) Chalybion cæruleum L. *Pompilidæ*: (6) Pompilus sp.; (7) P. navus Cr.; (8) Priocnemis fulvicornis Cr. *Scoludæ*: (9) Tiphia inornata Say. *Mutillidæ*: (10) Mutilla hexagona Say; (11) M. sayi Blake; (12) Sphærophthalma macra Cr. *Formicidæ*: (13, 14) A black and a large red species. *Chrysididæ*: (15) Holopyga ventralis Say; (16) Chrysis montana Aaron. *Braconidæ*: (17) Apanteles sp.

Diptera—*Tabanidæ*: (18) Tabanus lineola F. *Syrphidæ*: (19) Mesograpta marginata Say; (20) M. polita Say. *Tachinidæ*: (21) sp.; (22) Phorocera sp. *Sarcophagidæ*: (23) Sarcophaga sp. *Muscidæ*: (24) Lucilia cornicina F. *Anthomyidæ*: (25) Anthomyia sp. *Ortalidæ*: (26) Rivellia quadrifasciata Macq

Hemiptera—*Capsidæ*: (27) Lygus pratensis L.

Lepidoptera—*Rhopalocera*: (28) Callidryas eubule L. (Trelease notes.)

Cassia Marilandica[5] L.—Three petals form an upper lip, while two form a lower, all of them being entirely yellow. Fritz Müller[6] mentions several flowers in which there are two kinds of stamens with different functions. In this flower there are three sets of stamens, all with different functions. The three upper are reduced to dark scale-like rudiments, which serve as pathfinders. Accordingly, the red spots which occur on the upper petals of Chamæcrista are wanting in Marilandica. Four short stamens furnish pollen for the visitors. Bumble-bees milk the pollen out of these, using their jaws as in the case of Chamæcrista. Two long stamens, one on each side of the style, furnish pollen for cross-fertilization.

[5]See Meehan: Proc. Acad. Sci. Phil., 1886, 314-318. Also Torr. Bull. XIII, 249. Figures of the stamens and style of C. occidentalis and of the flower of C. acutifolia by Todd, in Am. Nat. XVI, 285, represent C. Marilandica fairly well.

[6]Nature XVII, 364.

They have inflated anthers, which probably have a bellows-like action like the long stamen of Solanum rostratum[7] and the anthers of Rhexia Virginica.[8] Between the style and a long stamen is another long stamen with an anther like those of the short stamens. Bees, no doubt, force the pollen out of this as they do from the short stamens. The style is turned sometimes to the right, sometimes to the left, and the flower itself is turned slightly to one side or the other, so that the stigma touches the side of the visitor, making the flower *pleurotribe*. According to Meehan, the flowers fail to produce seed under a net. Both he and Leggett[8] saw bumble-bees collecting the pollen. I have seen the flower visited for pollen by Bombus americanorum F. ♀.

Extranuptial nectaries.—Visitors:(on one occasion) A large red ant; Sarcophaga sp.; Anthomyia sp.; Camptoneura picta F. (Ortalidæ); Coccinella sanguinea L.

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Fermentation of bread.[1]

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Ferments have been known since very early times, for we have accounts of the early Egyptians using leaven to increase the lightness of bread. Much has been written and said in a superficial way about the fermentation of bread, and there are many methods of preparing and preserving leaven for bread-making given in old books, but what was in the leaven that produced the fermentation long remained an unsolved problem. Then came the early researches into the subject which established the now well-known facts that yeast causes carbon-dioxide and alcohol to be generated from sugar, that the carbon-dioxide causes the bread to rise, and that the alcohol is driven out of the bread by the heat in baking. The processes that the yeast and sugar underwent in causing the decomposition of the latter were not at that time understood, nor whether there were other organisms besides the yeast present.

Of late years, however, since bacteriology has received the attention of scientific men, the old view that yeast alone

[7] Todd: l. c. [8] Torr. Bull. V III, 102-104.

[1] Part of a thesis presented to the faculty of Purdue University for the bachelor's degree, based upon work done in the botanical laboratory under the direction of Dr. J. C. Arthur.